#2

Office de la propriété intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An Agency of Industry Canada

PCT/CA 03/01392
07 OCTOBER 2003 07-10-03

REC'D 22 OCT 2003
WIPO PCT

Bureau canadien des brevets
Certification

Canadian Patent Office
Certification

La présente atteste que les documents ci-joints, dont la liste figure ci-dessous, sont des copies authentiques des documents déposés au Bureau des brevets.

This is to certify that the documents attached hereto and identified below are true copies of the documents on file in the Patent Office.

Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,404,577**, on September 23, 2002, by **TESCO CORPORATION,** assignee of Maurice William Slack, for "Pipe Centralizer and Method of Forming".

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Agent certificateur/Certifying Officer

October 7, 2003
Date

Canada

(CIPO 68)
04-09-02

OPIC CIPO

ABSTRACT OF THE INVENTION

A hydroformed centralizer for installing on a thick-wall metal pipe. A method for hydroforming the centralizer. A centralizer formed by hydroforming.

PIPE CENTRALIZER AND METHOD OF FORMING

Field of the Invention

The present invention relates to centralizers attached to pipe placed in boreholes. The invention discloses a method of hydroforming centralizers and means of their attachment to pipe.

Background of the Invention

The processes of drilling and completing well bores in earth materials using tubular strings are frequently benefited if the tubular string is prevented from fully eccentering and generally contacting or laying against the borehole wall. Devices, typically referred to as centralizers, are employed to provide this function of reducing eccentricity, or *centralizing*, the tubular string within the borehole. These devices are configured to economically meet a variety of drilling and completion applications.

As disclosed in Canadian patent application 2350681, the demands of drilling with casing lead to the need for inexpensive casing centralizers which are rugged, comparatively easy to attach to the casing and able to withstand drilling rotation sufficient to complete at least one well.

It has subsequently been found that this method of manufacture can be implemented to manufacture centralizers that are cost effective for applications beyond drilling with casing.

Summary of the Invention

A hydroformed ribbed centralizer and method of manufacture has been invented. Said centralizer is suitable for installation on pipe, such as would be useful in well bore drilling and casing operations. The present invention provides a metal centralizer having a cylindrical body carrying outwardly projecting ribs, hydroformed into its sidewall, which when coaxially placed over a pipe may be retained by various means.

The means employed for attachment may be varied according to the needs of the application. For applications such as drilling with casing, typically requiring sufficient structural capacity to substantially prevent significant relative movement of the centralizer on the pipe, the centralizer body is provided with at least one cylindrical

interval suitable for attachment by the method of crimping as taught in Cdn. App. 2350681.

For applications where centralizer rotation is allowed or preferred, but axial position is fixed, the hydroformed centralizer is installed between stop rings, affixed to the pipe, as commonly implemented for casing running. Said stop rings may be fixed to the pipe by the method of crimping or by other means generally known to the industry such as set screws threadably mounted in the side wall of said stop rings.

Thus, in accordance with a broad aspect of the present invention, there is provided a centralizer comprising: a generally tubular body having a central opening sufficiently large to allow insertion therethrough of a selected pipe having an external diameter; a sidewall of substantially uniform thickness including an inner-facing surface directed to the central opening and an outer-facing surface onto which are formed a plurality of outwardly protruding ribs by means of hydroforming the sidewall; and having an internal diameter loosely fitting about the external diameter of the pipe.

The placement of ribs in the tubular wall is supported through provision of a specialized hydroforming process providing a means of creating ribs acting as centralizer bearing surfaces, suitably shaped to accommodate the structural and flow requirements encountered in well bores. In one embodiment, the hydroforming process comprises the steps of:

- first placing a length of metal tubular workpiece having a sidewall inside a confining surface comprised of mold elements having cavities spaced and shaped in the configuration of the desired side wall protrusions and positioned to generally align with the mid-section of the tubular work piece leaving fully supported cylindrical confinement opposite the tubular workpiece end sections and where the mold is contained within a confining tube supporting or guiding the mold elements creating the confining surface;

- second applying sufficient internal pressure to force or inflate the tubular sidewall radially outward against the confining surface and into the mold cavities and thus plastically form protrusions or ribs in the side wall of the tubular workpiece such that the original tubular length is substantially preserved;

- third removing the formed centralizer from the forming apparatus which removal may be facilitated by providing a close fitting tapered collet between the

confining surface and mold elements and means to axially displace the collet in the direction allowing radial expansion, and;

- fourth additionally finishing the formed centralizer, if required, by various means such as cropping, machining or applying coatings to improve wear resistant or reduce friction.

In one of its embodiments, it is a purpose of the present invention, to provide such hydroformed centralizers with at least one tubular interval along its length suitable for crimping, which interval is preferably located at one or both ends of the tubular body. It is further preferable if the material property of the centralizer body in the interval suitable for crimping is selected to have its elastic limit less than the pipe selected for insertion therethrough.

It is a further purpose of the present invention to provide means of mounting the centralizer body on the selected metal pipe which allows free rotation of the hydroformed centralizer on the metal pipe but limits its range of axial travel. Said means of mounting comprising placement of the centralizer on the metal pipe between two surfaces upset sufficiently with respect to the metal pipe external diameter to abut the ends of the centralizer body. Said abutting surfaces typically provided by the shoulders of stop rings placed coaxially on the pipe on either side of the centralizer said stop rings fixed to the metal pipe by means of set screws or bonding as well known to the industry but preferably by means of crimping. Said means of crimping said stop rings can follow the teachings provided in Cdn. App. 2350681. The selected metal pipe can be, for example, casing for drilling or lining a borehole or drill pipe.

Brief Description of the Drawings

A further, detailed, description of the invention, briefly described above, will follow by reference to the following drawings of specific embodiments of the invention. These drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. In the drawings:

Figure 1 is a perspective view of a centralizer according to the present invention;

Figure 2 shows a side view and crossection of the centralizer shown in Figure 1;

Figure 3 is a perspective view of another centralizer according to the present invention placed on a joint of casing as it might appear prior to assembly into a string being installed in a well bore.

Figure 4 is a perspective cutaway view through the wall of the hydroforming fixture with coaxially positioned tubular work piece (centralizer blank) installed. The view shows the mold elements and internal mandrel as they would appear prior to application of hydroforming pressure;

Figure 5 is a perspective view of the mold elements comprising part of the hydroforming fixture shown in Figure 4;

Figure 6 is the sectional view through the entire wall of the assembly shown in Figure 4 as it would appear before application of forming pressure;

Figure 7 is the sectional view through the entire wall of the assembly shown in Figure 4 as it would appear after application of forming pressure; and

Figure 8 is a perspective view of the centralizer shown in Figure 1 placed on a joint of casing between two stop rings as it might appear prior to assembly into a string being installed in a well bore.

Description of the Preferred Embodiment

According to the present invention, a hydroformed centralizer is provided as shown in Figures 1 and 2, for placement on a pipe as shown in Figure 3.

Referring to Figure 1, the centralizer is provided in its preferred embodiment having a metal body 1 containing an internal bore 2, cylindrical ends 3 & 4, and a main body interval 5 having a sidewall 6 into which outwardly projecting hydroformed ribs 7 are placed. In its preferred embodiment, one or both of cylindrical ends 3 & 4 can provide intervals suitable for crimping, if it is desired that the centralizer be installable for crimping.

Referring now to Figure 2, three ribs 7 are evenly spaced around the main body interval 5 where each rib extends along at least a portion of the length of the centralizer helically as commonly known to the industry. Preferably, the number, length and pitch of the rib helixes are arranged to ensure the starting circumferential

position of each rib overlaps the ending circumferential position of at least one adjacent rib. As shown in cross-section A-A of Figure 2, the hydroforming process allows ribs to be placed in the sidewall 6 with some thinning of the sidewall at the rib, but retaining a generally uniform thickness. Thus configured, the ribs provide a bearing surface 8, suitably shaped to accommodate the structural and flow requirements encountered in well bores.

In applications where the centralizer is rotated with the pipe, such as required for drilling with casing, the bearing surfaces 8 may be provided with a wear resistance coating such as hardfacing to protect the ribs 7 from wear against the borehole wall. Referring now to Figure 1, in applications where rotation of the centralizer on the casing is permitted and thus subjecting the internal bore 2 to potential wear against the pipe, the surface defining the internal bore may be provided with a suitable coating [2a] such as for example polyurethane.

Referring now to Figure 4, the placement of such ribs in the tubular wall is supported through provision of a fixture 100 enabling implementation of a specialized hydroforming process. The fixture includes an assembly of close fitting largely cylindrical components. Beginning with the innermost and progressing outward, these components are: a mandrel 101, the centralizer metal body 1 as a work piece (provided as a metal tubular 'blank'), a mold assembly 103 comprised of elements 107 & 108, an externally tapered collet 104 comprised of an assembly of jaws 105 and a confining vessel or bell 106 internally tapered to mate with the collet. Additionally, a means to apply axial displacement between the collet 104 and bell 106 is provided, using say a double acting hydraulic actuator (not shown). As will be apparent to one skilled in the art said axial displacement is converted to radial displacement by the collet jaws 105 moving in contact with the bell 106 facilitating installation and removal of the close fitting parts.

Referring now to Figure 5, in its preferred embodiment the mold assembly 103 is comprised of two elements 107 & 108 mating at split line 112 and having three helical cavities 109, generally shaped as the inverse of the desired rib geometry. The cavities can be closed or open through the mold, as shown. Removal of the mold elements after hydroforming the centralizer is facilitated by the slits 113 that act to introduce hoop compliance.

Referring now to Figure 6, the mandrel 101 is provided with internal seals 110 engaging the inside bore 2 of the work piece blank 1 and a fluid entry port 111. Fluid applied through this port is thus contained by the mandrel 101 and seals 110, they being in sealing engagement with the work piece 1, allowing application of fluid pressure to the internal surface of the workpiece 1 by suitable means such as may be provided by a high pressure air over hydraulic pump.

Referring now to Figure 7, application of sufficient fluid pressure through port 111 causes the work piece 1 to expand and plastically deform unless constrained by contact with the internal surface of the containing mold, thus inflating the sidewall of the work piece 1 into the mold cavities 109 to form ribs 7 in the centralizer main body 5. The portion of the pressure force reacted by the mold 103 is in turn reacted through the collet 104 into the bell 106. Due to the tapered interface between the collet 104 and bell 106, the collet 104 may tend to slip in the bell 106 while under pressure load allowing unwanted expansion of the work piece 1. This movement may be readily prevented by application of axial load or other suitable means of restraint between the collet jaws 105 and bell 106. Upon removal of the forming pressure, the mandrel 101 is readily removed, however a residual radial stress or interference may exist between the work piece 1 and mold 103 tending to resist removal of the work piece 1 and mold 103 from the collet 104. This radial stress is relieved by appropriate displacement of the collet relative to the bell enabling removal of the work piece 1 together with the mold elements 107 & 108, since the formed ribs 7 are interlocking with the mold cavities 109 after forming. Once removed from the forming fixture 100 the mold elements 107 & 108 may be removed from the formed centralizer main body 5.

Referring now to Figure 1, the internal bore 2 of the formed centralizer body 1 is arranged to loosely fit over at least one end of a pipe, referring now to Figure 3, shown as a threaded and coupled casing joint 9. This allows the centralizer to be readily placed somewhere along the length of the casing joint 9. When the casing joint is made up into a string, the centralizers are free to rotate and are constrained to slide between the couplings connecting the casing joints, which method of incorporating centralizers into a string is well known in the industry.

For applications requiring structural attachment of the centralizer 1 to the casing 9 enabling torque transfer, the centralizer is preferably fixed to the casing by crimping

one or both of the end intervals 3 & 4 onto the casing as described in Cdn. App. 2350681. For such applications the material of the centralizer body 1 in one or both of the end intervals 3 & 4 is preferably selected to preferably have its elastic limit less than that of the casing joint 9.

As an alternate method of attachment providing axial load and torque transfer, one or both of the end intervals 3 & 4 may be provided with set screws (not shown). Once positioned on the pipe, the set screws are tightened to fix the centralizer in place, which method of attachment is well known to the industry. Similarly the centralizer may be secured by use of welding or by injecting grout or other adhesive into the interface between the centralizer bore and casing, which method of affixing centralizers is also known in the art.

In a further embodiment of the present invention, for applications requiring axial position control of the centralizer on the pipe but allowing rotation without significant torque transfer, referring now to Figure 8, cylindrical stop rings 10 are provided and placed on the pipe with the centralizer 1 therebetween. The stop rings 10 are affixed to the casing in a manner preventing axial sliding. In one embodiment, the stop rings are provided with set screws 11 and affixed to the pipe in a manner well known to the industry. In their preferred embodiment, the stop rings 10 are provided without set screws 11 and made from a ductile material suitable for attachment to the pipe by crimping.

It will be apparent that these and many other changes may be made to the illustrative embodiments, while falling within the scope of the invention, and it is intended that all such changes be covered by the claims appended hereto.

Claims:

1. A centralizer comprising: a tubular body of generally uniform thickness having a central opening therethrough sufficiently large to allow insertion therethrough of a selected metal pipe having an external diameter; a sidewall of substantially uniform thickness including an inner-facing surface directed to the central opening and an outer-facing surface onto which are formed a plurality of outwardly protruding ribs by means of hydroforming the sidewall; and having an internal diameter loosely fitting about the external diameter of the pipe.

2. A method for producing a centralizer for a pipe comprising: providing a tubular workpiece selected to be formed into the centralizer having a central opening defining an inner diameter and a sidewall having an inner-facing surface directed toward the central opening and an outer-facing surface; providing a mold including a plurality of elements together forming a inner-surface defining a substantially cylindrical confining space and cavities formed in the inner surface positioned and configured so as to correspond to the position and configuration of ribs to be formed on the centralizer; positioning the tubular workpiece and the mold elements such that the tubular workpiece is within the substantially cylindrical confining space formed by the mold elements; securing the mold elements about the tubular workpiece; applying sufficient fluid pressure against the sidewall to force the sidewall out against the mold elements and into the cavities of the mold elements to form a centralizer having ribs protruding outwardly from its outer surface; and removing the centralizer from the mold elements.

3. A centralizer formed by the method of claim 2.

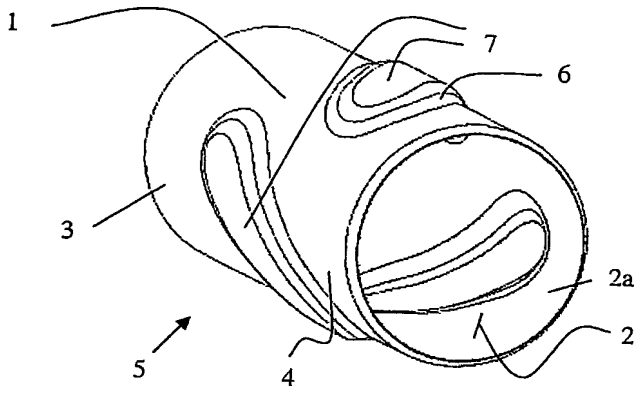

Figure 1

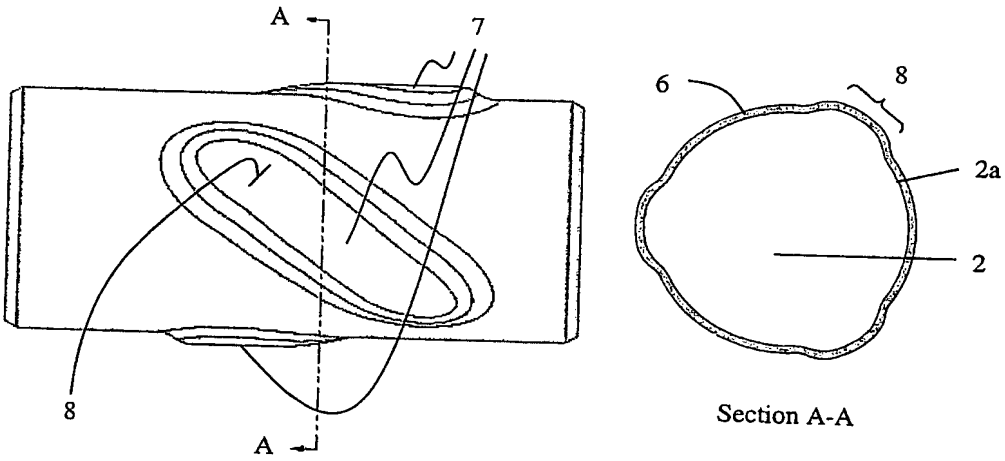

Figure 2

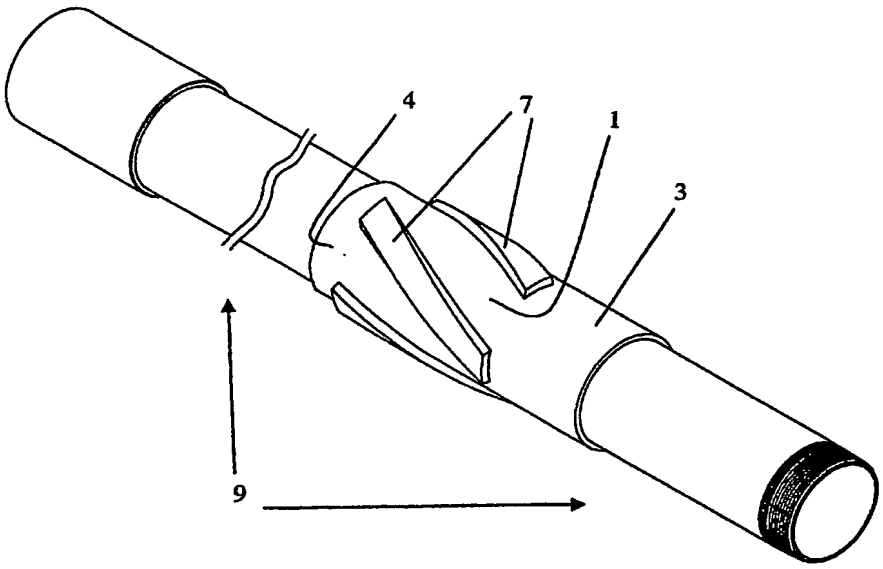

Figure 3

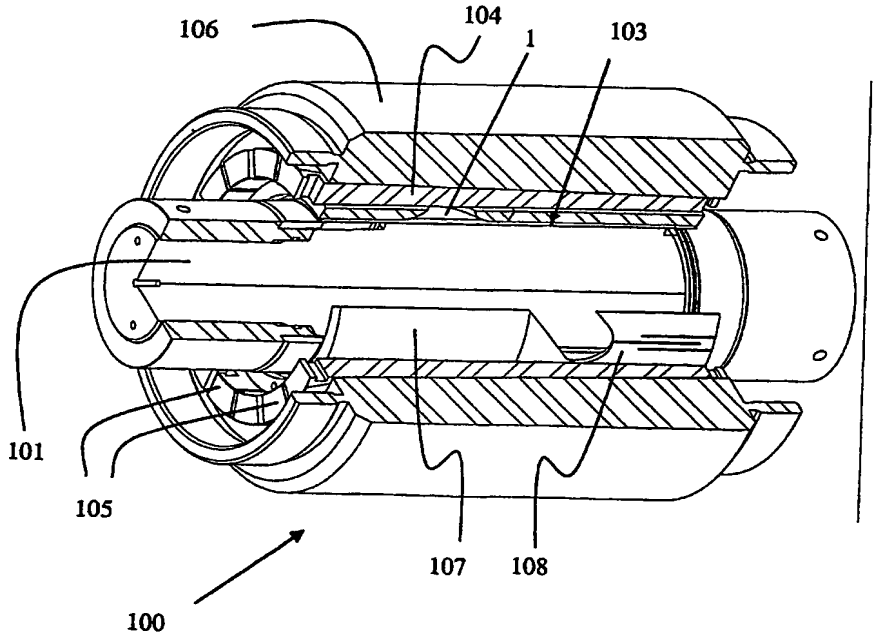

Figure 4

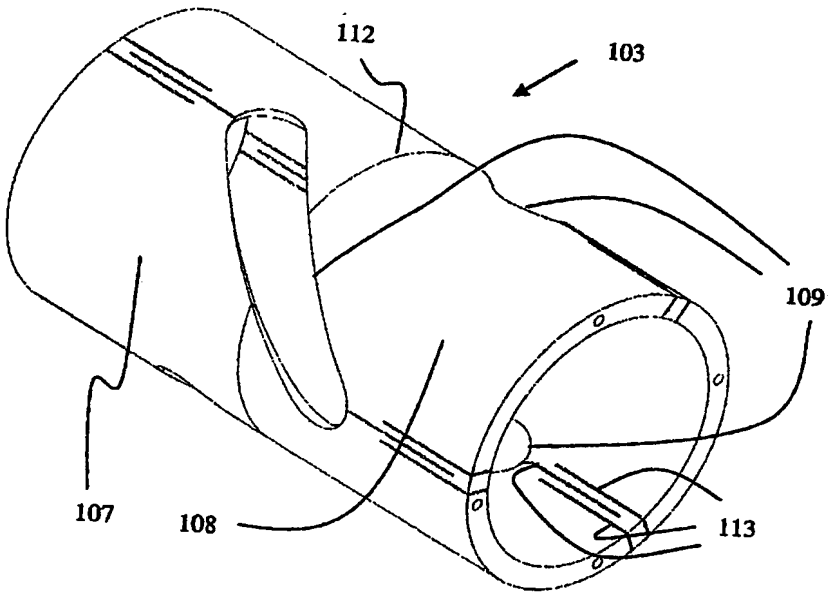

Figure 5

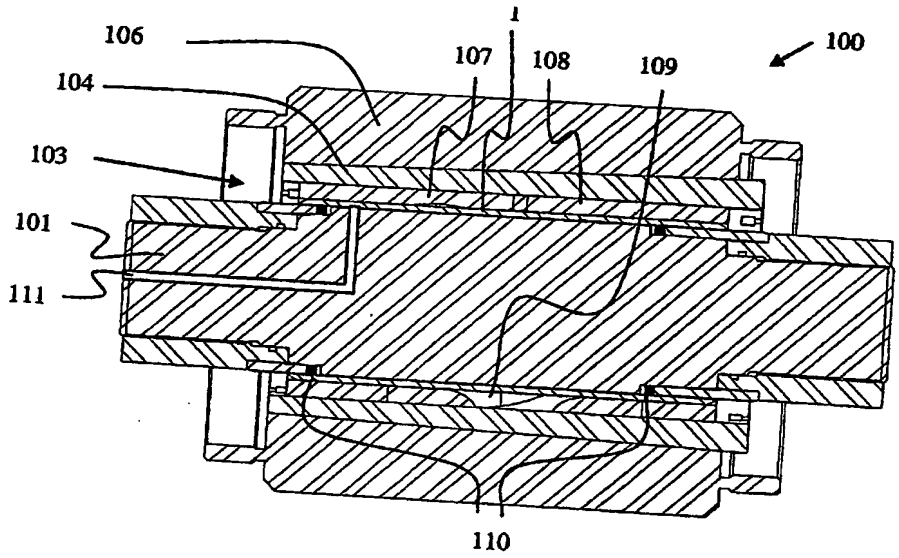

Figure 6

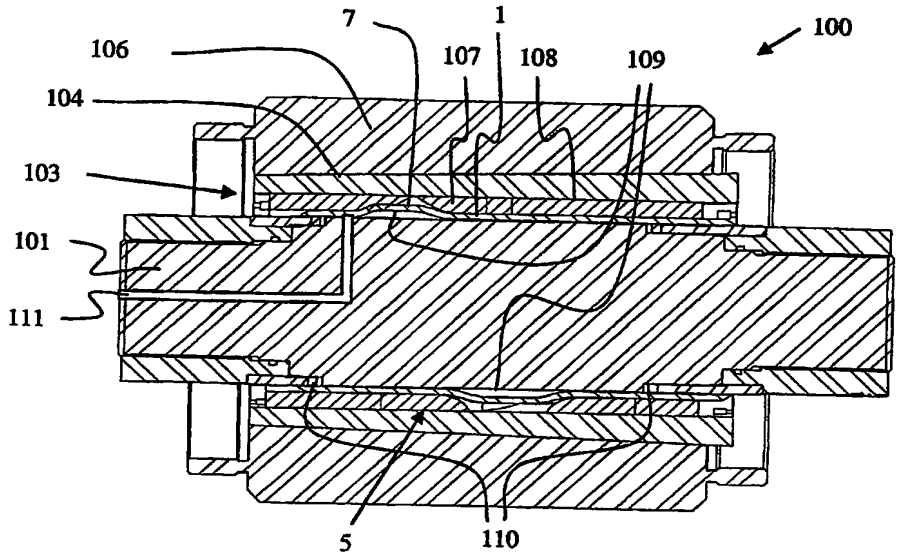

Figure 7

Figure 7

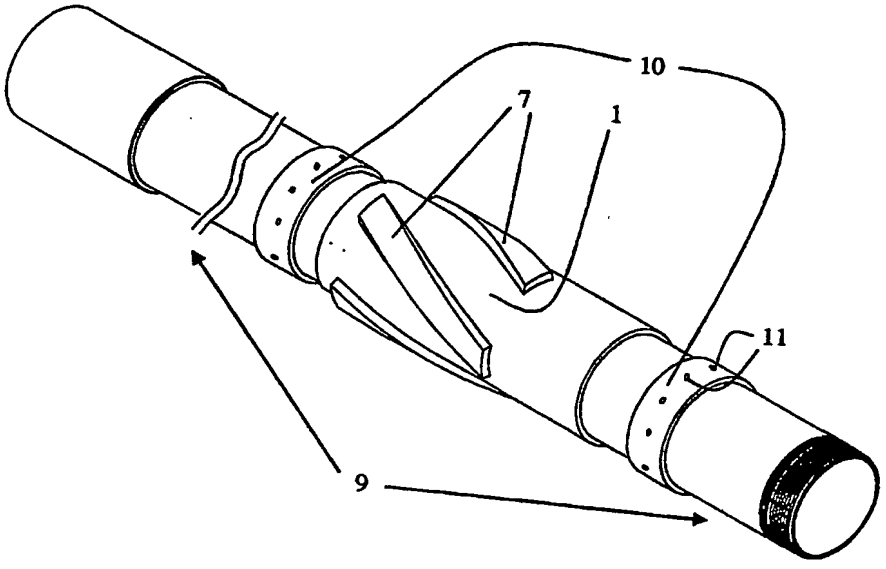

Figure 8